QUANT-THEORY – MATERIALISM, PHILOSOPHY AND QUANTUM SCIENCE (2)

all, GenericScience / 2024-02-22 / materialism, object, quantum, relation, strucutrualism / Von Achim Szepanski

Exzerpt from the forthcoming book: “Quant-Theory – Materialism, Philosophy and Quantum Science”

Let us now take a closer look at the question of indeterminism in quantum theory. In his book Theory of the Object, Thomas Nail assumes that matter can be understood neither by determinism nor by randomness, but only as relational indeterminacy. (Nail 2021) He agrees with the quantum theorist Carlo Rovelli insofar as he presents relationality and indeterminism as two of the three essential principles of quantum theory. (Rovelli 2016: 147f.) However, for Rovelli, granularity is the third principle of quantum theory, while Nail allows discrete states, which he calls a meta-stable state of the object, to merge into a continuous molecular flow of flows. For Rovelli, on the other hand, who adopts a realist position here, space is discrete and not continuous. For Roveli, the fact that the interactions between objects are discrete and quantized is an empirical fact, with Planck’s quantum of action being its theoretical expression. And every field consists of quanta that have a fine-grained structure. However, in the fundamental equations of quantum theory, there is neither space, which contains things like a container, nor time, in the course of which phenomena occur. (Rovelli 2018) Rovelli links quantum indeterminism with (measurable) probability. In quantum mechanics, you can only calculate the probability of an event taking place. You can use the mathematical formalism for a measurement to make predictions about the value of the position variable of a certain quantum object at a certain future point in time. These are predictions that are generally probabilistic in nature. And the calculated values are those that a variable can assume at the moment in which an object interacts with another (relationality). (Rovelli 2016: 147f.) We are not dealing here with an arbitrary renunciation of a more precise

analysis of atomic phenomena, but with the realization that such an analysis is ruled out in principle. Since Dirac, it has been possible to calculate the probability with which a variable assumes this or that value when one object interacts with another. Rovelli's indeterminism indicates that there are no definite predictions, only probable ones. And a photon only appears at a certain location when it collides with another. And this cannot be predicted with certainty. Like Nail, Rovelli quotes the Greek Lucretius here, who speaks of the deflection that takes place at an uncertain time and in an uncertain place. All paths that an electron can take between A and B are considered, whereby there is a finite number of possibilities for each path, the total sum of which makes it possible to determine probabilities. The electron is treated as if it could pass through all paths on its way from A to B and dissolve into a cloud and then approach B in a mysterious way. We will come back to the "as if" later. The mystery here would be the infinity of possibilities of the photon.

The indeterminism of quantum theory must also be distinguished from Gödel's definition of undecidability. Thus, the indeterminacy of particle and wave representations is an important part of the quantum matrix. It is probably crucial that "particles" are both – particles and waves – which is more likely than that they are perhaps ultimately neither. However, indeterminacy is itself also determined, but determined not only in the more or less obvious sense that relations are determined as indeterminate (possibly undecidable), but also in the sense that relations contain specific complementarities and their constituent "idealizations" as mathematical, experimental, conceptual and metaphorical complexes. Such complementarities can be used in the deconstructed or undecidable domain, or, more directly, in what might be called the complementary field. (Plotnitsky1994: 198)

Nail, in contrast to Rovelli, does not speak of the granularity or granularity of photons with regard to matter, but of a continuous flow as the most important principle of matter, and mentions that objects can never be completely discrete.

(Nail 2021: 220ff.) Moreover, his indeterminism is not one of probability, but is to be understood ontologically. For Dirac, position, velocity, momentum and electric potentials can only be determined if the relation of objects to other objects is taken into account. Nail describes this as a completely relativistic quantum theory for quanta-in-transition. For Dirac, a quantum field behaves like a vibrating string whose frequencies only lead to the formation of particles or to certain levels of energy.

Rovelli also speaks of the interaction of things, which does not show where a particle is, but takes into account where it is in relation to other particles. (Rovelli 2016: 150) This is about the “how” of a reciprocal influence. With Barad, the concept of reciprocity would be preferable to the term interaction, which can create the illusion of separate parts. For Rovelli, there is no reality at all without including the relations of objects to one another, i.e. it is not the objects that relate to one another, but rather their conception emerges from the relations. Reality is interrelation and interaction, or rather relation. Objects do not have an autonomous reality, rather they only exist thanks to, dependent on and from the perspective of other objects with which they interact. For Rovelli, all the properties of an object only really exist in relation to other objects.

Here Rovelli is close to the “ontic structural realism” of James Ladyman, who writes that every “thing” must disappear because the world does not consist of things in the sense of small material objects as modeled by intuition – particles are not intrinsically individuated things, nor is there an intrinsic individuation by means of properties. Properties are only revealed by means of structures that constitute them. (Ladyman 2008) Ladyman claims that the world does not consist of a series of entities with a nature of their own, but rather that the world has a relational structure that is described by our mature scientific theories. Basically, this aims to deny individual objects an ontological priority and to enhance the on-

tological status of the relational structure. But is this structure not one of the very real virtuality that actualizes relationships? It then functions as a field of potentials full of tensions, full of dissonances, full of noise.

Against Kant, it is argued that scientific theories should not be regarded as descriptions of the relationships between unknown, unobservable entities (thing-in-itself). All Kant can say about things in themselves is that we cannot say anything about them. For Ladyman, on the other hand, reality has relationships or a mathematical structure. This constitution can either be ideally represented and thus known through a theory, or it can be unrepresented or unknown or even unrepresentable but still conceivable, usually with the hope that it will eventually be represented and known. From this perspective, there is a danger that the technology also used in quantum physics as an applied science is the practical result of purely logo-theoretical work, namely the application of a logocentric interpretation of the world. A mediating position between Kant and Ladyman would be to understand the unknown as an epistemological category. A concept has a syncategorematic meaning when the meaning emerges through contrast; we never have the final meaning of a concept or the final form of an idea, for the world is never complete in its emergence, but there are only distinguishable individuable moments in the journey of the world in which it seemingly takes on a specific form, whereby the condition for the specificity of the form remains that it is contrasted by foreign forms.

Ladyman ultimately speaks of a modal or nomological structure, and not just a mathematical structure. It could be, however, that the necessity of mathematics and the physical necessity of laws coincide. Ladyman’s naturalistic metaphysics is thus motivated by the content of physics. However, if the mathematical structure does not coincide with the physical structure, then for Ladyman the relationship between them is at least that of isomorphism.

Ladyman wants to prove that the view of quantum physics as an ontology of objects is (metaphysically) under-determined. (Ladyman/Ross: 2007) It is not possible to say whether objects are individuals or not. On the one hand, microphysical systems can be individuals insofar as properties are always those of featureless systems. Entangled systems of the same kind can be individuals that do not differ in terms of their properties, but their respective identity is something that goes beyond these properties. On the other hand, a system is nothing more than a bundle of its properties. If individuality is understood in this sense, then entangled systems of the same kind are not individuals. On the one hand, they do not differ in their time-independent properties such as mass and charge. On the other hand, they also do not differ in their time-dependent properties such as spin. Subsystems that are entangled have no spin properties independent of each other.

It therefore remains undetermined whether objects are individuals or not. However, if the ontology of quantum physics is understood as an ontology of relations, then the question of individuality and consequently of under-determination no longer arises. Ladyman assumes that in the existence of competing ontological assumptions, cases of under-determination should be avoided and one should agree on the ontology of quantum physics as an ontology of relations. (Ibid.)

If, on the other hand, one considers the ontology of quantum physics as an ontology of objects, which leaves quantum physics under-determined (which is an epistemic question), then the ontological hypothesis that the ontology of quantum physics is not an ontology of objects but one of relations is not necessarily true. Truth does not only arise because of the question of under-determination.

In a metaphysically inspired question, two levels of under-determination arise. On the one hand, the under-determination of the truth of scientific theories by empirical evidence, and on the other hand, the under-determination of the truth of metaphysical theories by scientific theories. With regard to the first aspect,

quantum physics is a scientific theory only through an ontological interpretation of the mathematical formalism. With regard to the second aspect, it should be pointed out that the correctness of an interpretation of quantum physics does not already determine how the world is (metaphysically) constituted. Quantum physics must develop a scientific theory of the world, and this is linked to the measurement problem. There are several interpretations, all of which are consistent with our previous experimental results. This means that empirical evidence alone does not commit us to one interpretation or another. Ladyman's naturalized metaphysics remains under-determined, even if one assumes that his preferred many-worlds theory is correct, insofar as it cannot say conclusively how the world is metaphysically constituted on a microphysical level.
The entangled states and relations of quantum mechanics have no direct influence on the intrinsic properties of their relations, because in an entangled state each particle has no state of its own, but has entered a multiplicative product state. The question that arises if the structures are primary is whether only the properties of the objects are defined by relations or the objects/relata themselves, from which it could then be concluded that only structures exist, whether they are to be understood epistemologically or in real terms.

We can initially assume that the properties of objects are intrinsic, but also have a relational quality. They are relational insofar as the dispositions that things have due to these properties are regulated by the relationships they enter into. Knowledge of these relations thus gives us insight into the state of the objects. If these relations are not given, we cannot speak of structures. Although objects have intrinsic properties (mass, charge, etc.), they are determined in particular by whether or how they can be described structurally. A structure is not an object in itself, but rather a way in which objects/relata are set in relation to each other. Quantum theory, however, leaves undetermined whether quanta are objects at all. Ladyman claims that in the case of state entanglement there are no relations

(objects) at all, but only relations (structure). Relata would always turn out to be relational structures in a certain relationship. In the physical sense, there is something that exists independently of spacetime distances, i.e. that is not localized in clearly definable spacetime regions.

In quantum mechanics, the subsystems that make up an entangled system have no individual wave function and therefore no intrinsic properties. The wave itself is not an object, as it does not consist of permanent matter. Moderate (realist) structuralists are of the opinion that objects are to be understood as non-individualized relations of a common entanglement structure. There are objects, but they are nothing beyond what they are in terms of relations. The fundamental objects and spacetime points are thus characterized only by their relational properties. The objects that make up the whole have some of their constitutive properties only within the whole. The properties in question are therefore relational properties. They consist in relationships between the objects that make up the whole in question.

If the wave function is defined by laws and the associated symmetry principles, then it is defined by the structure. In structuralism, the symmetries (relations) are ontologically prior to the objects, so that the structure together with the symmetries generates the laws, the objects and the properties. The structure is a network of relational properties (not intrinsic) between objects that are defined by them. Objects may have intrinsic properties such as mass or charge, but they are mainly defined by the relations that represent the way an object can be. This concerns properties (velocity, momentum and electric potentials) that can only be determined relationally. Moderate structuralism still recognizes relata in contrast to hard realist structuralism, for which there are no relata but only relations, whether of the epistemological or realist/ontic variety, relations that can be understood as abstract universals. If, at least for moderate structuralism, there are

still relations, what about the properties of these relations as objects? For Rovelli, it is precisely these that are determined by the relations.

translated by deepl.

ARCHIVE

Monat auswählen